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# Peristaltic Pump

The invention refers to a peristaltic pump according to the preamble of claim 1.

Peristaltic pumps of the kind discussed herein are fundamentally known. They are used for conveying different liquid and gaseous media.

A fundamental disadvantage inherent to peristaltic pumps is that the conveying volume is not constant, but pulsates more or less. Moreover, the torque to be delivered by the drive motor per revolution is subject to certain variations; this is not desired as well.

From the DE 198 14 943 A1, a tube pump of the kind referred to herein is known. The pump is provided with a pump housing, in which the pump tubing as well as a rotor comprising two squeezing means in the form of rollers is received. The two squeezing means are located one diametrically opposite to the other one. In order to enable a conveying operation as continuous as possible, it is proposed to increase the cross sectional area of the pump tubing in the region where it enters the squeezing means. Thereby, in that input region, an increased volume for conveying shall be allocated, and a flow-back of the medium from the outlet region into the pump tubing shall be prevented. Irrespective whether or not the desired effect can be realized with the described characteristics, the torque to be delivered by the drive motor per revolution is subject to substantial variations. Moreover, the manufacture of such pump tubing probably is very complex. Also, care has to be taken that the pump tubing is placed with high positional accuracy into the pump. Since tubes have the tendency to become longer the longer they are used, the danger exists that the enlarged tubing portion dislocates during extended use whereby the desired effect is lost.

It is the object of the present invention to improve a pump designed according to the preamble of claim 1 in such a way that it provides a conveying with low pulsation, that it is not wearing out rapidly and has a high efficiency, that commercial pump tubing can be used, and that the torque peaks to be delivered by the drive motor per revolution are minimal.

This object is met with a pump which comprises the characteristics listed in the characterizing portion of claim 1.

Advantageous further developments of the peristaltic pump are defined in the dependent claims 2 to 14.

In the following, a preferred embodiment of the invention is further explained by means of drawings. In these drawings is shown in:

Fig. 1 an exploded view of the peristaltic pump;

Fig. 2 the assembled pump according to Fig. 1 in a first cross sectional view; and

Fig. 3 the assembled pump according to Fig. 1 in a further cross sectional view.

Fig. 1 shows a six channel peristaltic pump in an exploded view. Substantially, the pump consists of a support frame 1, a tubing holder 2, a rotor 3 and a connecting element 4 having six tubing sections 43 located thereon. Also evident is a gear wheel 5 for coupling to a not shown driving motor.

The support frame 1, designed to be dimensionally stable, constitutes, together with the tubing holder 2, the real housing of the pump. For rotatably supporting the rotor 3, the support frame 1 is provided with two bearing sleeves 11. The two front faces of the support frame 1 are constituted by panels 12, which are provided with slots 15a, 15b for fixing the support frame 1 and the entire pump, respectively. Finally, the support frame 1 is provided with several slot-like cut-outs 13 on both sides, in which notch elements 22 of the tubing holder 2 are clampingly fixable, as will be described further in the following.

The tubing holder 2 comprises a tubing bed body member 25, which is designed essentially in the shape of an Omega and which extends at the inner side in the shape of a circular arc coaxial to the axis of rotation of the rotor 3 over an angle of appr. 130° to constitute a tubing bed. The expression "in the shape of an omega" means in the present case that the tubing bed body member 25 has substantially the shape of a capital omega (Ω). In the end region, the tubing bed body member 25 presents two legs 2a, 2b which, from the inside to the outside, pass over from a concave shape to a convex shape in a smooth transition. The tubing bed is divided into six sections by means of groove-like recesses 21 which serve to receive the flexible tube sections. In place of the groove-like recesses 21 for constituting six sections, also a tubing mat, consisting of six tubes connected to each other, could be used. In this case, the tubing bed body member 25 could be provided with a substantially smooth inner side. The two legs 2a, 2b of the tubing bed body member 25 are provided, on the outer side, with notch elements 22 by means of which the tubing holder 2 is fixable to the slot-like cut-outs 13 of the support frame 1. The outer side of the tubing bed body member 25 is provided with radially extending reinforcing ribs 23 as well as with axially extending reinforcing ribs 24. The radially extending reinforcing ribs 23 extend along appr. 180° of the outer side of the tubing bed body member 25. In any case, the tubing holder 2 is dimensioned such that the ends of the two legs 2a, 2b of the tubing bed body member 25 are resiliently flexible in radial direction and make possible a quick fixing of the tubing holder 2 to the support frame 1 in the sense of a snap-on connection.

The rotor 3 consists of a rotor body 31, provided with a central axis 32 which is inserted into the bearing sleeves 11 of the support frame 1. Three conveying rollers 33, designed in the shape of barrels, are rotatably supported on the rotor body 31. Preferably, the rotor body 3 is manufactured of plastic material, while the central axis 32 as well as the conveying rollers 33 preferably consist of metal.

The connecting element 4 consists of a base element 41, to which are fixed twelve pipe sections 42. Attached to the upper portions of these pipe sections 42 are a total of six flexible tubing sections 43, which rest on the inner side of the tubing bed body member 25, once the pump is assembled, and which are squeezable by the conveying rollers 33 for the peristaltic conveying of a medium. It is understood that the design of the inlet and the outlet section is not limited to a six channel pump, but the number of the channels is substantially arbitrarily variable.

The assembly of the shown components to a pump can be accomplished with a few simple steps; first, the particular tubing sections 43 are attached to the connecting element 4 and then, the rotor 3 is transversely moved into the tubing sections 43 forming loops. Thereafter, the tubing holder 2 is U-shapedly positioned and the rotor 3, together with the

connecting element 4 and the tubing sections 43 attached thereto are slid in from the top. Subsequently, the support frame 1 is positioned upright and a pressure is applied, such that the axis 32 of the rotor 3 as well as the notch elements 22 snap in. Finally, the connecting element 4 is fixed to the support frame 1. In the embodiment shown here, the connecting element 4 is fixed by means of screws. Alternatively, a snap-on connection can be provided for fixing the connecting element 4, which ensures a quick connection of the connecting element 4 to the support frame 1. The entire assembly of the pump can be performed very quickly, without the use of tools, from one side, which constitutes an advantage in the case of an automatic manufacture.

Fig. 2 shows a first cross sectional view of the assembled pump. In this view, particularly the rotor body 31 together with the three conveyor rolls 33a, 33b, 33c rotatably attached thereto and squeezing the particular tubing section 43 in a rolling motion, the tubing holder 2 with the omega-shaped tubing bed body member 25 as well as the radial and axial reinforcing ribs 23, 24 are evident. The reinforcing ribs 23, 24 ensure that the tubing holder is dimensionally stable and does not deform in operation under the load of the conveyor rollers 33a, 33b, 33c. Assuming a sense of rotation D in counterclockwise direction, as it is the case in the present example, the region designated by reference numeral 35 constitutes the inlet portion, while the region designated by reference numeral 36 constitutes the outlet portion of the pump. Due to the omega shaped design of the tubing bed body member 25 with "soft" inlet portion and outlet portion, a continuous substantially pulsation free conveying of the particular medium is ensured. A further advantage of the soft inlet and outlet portions is the reduction of torque peaks which, otherwise, would load the motor and the gear box. The pump can be operated both in clockwise direction and in counterclockwise direction.

A soft and continuous inlet portion and outlet portion means that both the inlet portion 35 and the outlet portion 36 are designed such that the tubing cross section relevant for conveying is continuously decreased and increased, respectively, by the conveying roller 33a, 33c rolling along the particular flexible tubing portion 43. In this connection, it is important that the tubing bed body member 25 is accurately manufactured and that it exhibits a high dimensional stability in operation such that the predetermined distances between conveying roller 33a, 33b, 33c and tubing bed body member 25 are maintained.

Besides the already mentioned advantage, further advantages result from a continuous inlet portion and outlet portion; for example, the torque fluctuations emerging from the rotation of the rotor 3 are minimized. This is additionally favored by the facts that the rotor 3 is provided with three conveying rollers 33a, 33b, 33c and that the inlet portion 35 is offset around the axis of rotation of the rotor 3 by about 240° relative to the outlet portion 36, such that the first conveyor roller 33a is located approximately in the middle of the inlet portion 35 when the third conveyor roller 33c is located approximately in the middle of the outlet portion 36. By means of the design shown in the drawings, moreover, a high efficiency is realized and the mechanical load on the tubing sections 43 is reduced, thus increasing their service life. Since the pump is designed symmetrically, it can be operated bi-directionally, i.e. in both senses of rotation. Additionally, as the view shown in Fig. 2 exhibits, that the particular tubing section 43 is not fully squeezed in the inlet portion 35 and in the outlet portion 36, while it is fully squeezed after the inlet portion 35 by the corresponding conveyor roller 33b to enable a peristaltic conveying of the particular medium. A pump designed in such a way is also particularly suitable for conveying fluid media in a way gentle to cells, for example blood, because the blood corpuscles are prevented from damage by the particular design of the inlet and outlet portions 35, 36.

The design of the tubing holder 2 with a dimensionally stable tubing bed body member 25 and with elastically resilient legs 2a, 2b ensures a very quick and simple assembling, i.e. by simply clicking in the tubing holder 2 into the support frame. Even if the legs 2a, 2b have to be elastically resilient for assembly, the tubing bed body member 25 has to maintain its dimensional stability and a precise geometry. This goal is met, amongst else, by the fact that the elastically resilient parts are positioned and stiffened by means of an outer positive fitting support on the support frame 1.

From Fig. 3, showing a cross sectional view of the assembled pump taken between two tubing sections 43, particularly the clamping fixation of the tubing bed body member 25 to the support frame is evident. The notch elements 22 located at the outside of the tubing bed body member 25 engage the slot-shaped cut-outs 13 of the support frame 1. Moreover, the notch elements 22 positively engage an upper web 14 of the support frame, delimiting the slot-shaped cut-outs 13. In order to ensure a high stiffness in the flexible region of the tubing bed body member 25 fixed to the support frame 1, the legs 2a, 2b of the tubing bed body member 25 are positively supported at the outside by the web 14 of the support frame 1. This design particularly also ensures a precise observation of the optimized distances between the conveyor rollers 33a, 33b, 33c and the tubing bed body member 25.

The individual elastic tubing sections 43 additionally support the fixing of the tubing bed body member 25 at the support frame 1, since the conveyor rollers 33a, 33b, 33c of the rotor 3 load the tubing bed body member 25 in radial direction via the tubing sections 43, such that the fixation thereof to the support frame 1 is additionally supported.

The connecting element 4 is designed such and matched to the tubing holder 2 and to the rotor 3 such that the individual tubing section 43 is led essentially in tangential direction into the tubing bed body member 25 of the tubing holder 2 and also led out there from.

Even if, in the foregoing, reference has made to the embodiment shown in the drawings of a pump with three conveyor rollers, it is understood that the number of conveyor rollers can be practically arbitrarily varied as long as one stays within the scope of the present invention defined in the claims. Thereby, the tubing bed body member 25 has to enlace the rotor 3, depending on the number of conveyor rollers, to such a degree that always at least one conveyor roller 33a, 33b, 33c is active, i.e. engages the particular tubing section and squeezes it. The minimal enlacement and the minimum angle of enlacement, respectively, can be calculated as follows:

Enlacement = 360° / number of conveyor rollers.

In the case of using such a pump for higher pressure, moreover, it can be advantageous to have always two conveyor rollers engage the flexible tubing section. In this case, the enlacement can be calculated by using the following formula:

Enlacement = 2x360° / number of conveyor rollers.

The calculated enlacement is to be understood as a minimal amount of enlacement. Preferably, the enlacement is chosen about 10° higher than the angle of enlacement calculated by means of the foregoing formula. The expression "enlacement" shall be understood as that part of the tubing bed that coaxially surrounds the rotor.

- In recapitulation, it may be noticed that a pump designed according to the invention allows a conveying with low pulsation, that it has a high efficiency, is barely subject to wear and shows only low torque variations. Moreover, it is of simple and compact design, consists of few parts and can be assembled from one side quickly and without tools, such that it is also particularly qualified for automatic manufacturing. Also, the housing of the pump, consisting of support frame 1 and tubing holder 2, shows a high dimensional accuracy and stability after having been assembled. In addition, the pump can be bi-directionally operated and universally used. It is particularly useful for conveying delicate fluids like for example blood, where the corpuscles have to be treated with care.